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**THE EFFECTS OF WEARING  
THE CHEMICAL PROTECTIVE  
MASK AND GLOVES  
ON COGNITIVE PROBLEM SOLVING**

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**U S ARMY RESEARCH INSTITUTE  
OF  
ENVIRONMENTAL MEDICINE  
Natick, Massachusetts**

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**TECHNICAL REPORT**

**ND.T20/87**

**THE EFFECTS OF WEARING THE CHEMICAL PROTECTIVE MASK AND GLOVES  
ON COGNITIVE PROBLEM SOLVING**

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## ABSTRACT

The present study investigated the effects of wearing various combinations of the chemical protective mask and gloves on the speed and accuracy of solving cognitive problems. All testing was conducted at 72 degrees Fahrenheit. The results show that wearing the chemical protective mask and gloves or wearing the chemical protective gloves only, significantly degraded the rate (i.e., speed) of completing cognitive problems when compared to the bare handed/bare headed control. Wearing both the mask and gloves degraded the rate of task completion by 10% while wearing the gloves only resulted in a degradation rate of 8% compared to the bare handed/bare headed control. The accuracy of the cognitive problems completed was not significantly influenced by wearing any of the combinations of the mask and gloves. The decrement in performance is likely due to an impairment in manual dexterity and not in cognitive processing.

Chemical protective (CP) clothing systems provide individual protection against toxic hazards encountered in both the military and industrial workplace. The U.S. Army doctrine combines various CP clothing items into four Mission Oriented Protective Postures (MOPP) characterized by separate levels of protection which progressively achieves total encapsulation in the MOPP level 4 configuration. MOPP 1 consists of wearing a charcoal impregnated overgarment, MOPP 2 entails wearing the overgarment and rubber overboots, MOPP 3 is characterized by wearing the overgarment, overboots, and mask with hood, and in MOPP 4 the overgarment, overboots, mask with hood, and rubber gloves are worn. Although MOPP levels provide varying degrees of physical protection, the performance of soldiers while wearing MOPP gear is compromised by both physiological and psychological factors. It has been well documented that the relative impermeability of CP clothing adversely effects thermal regulation in hot environments (Goldman and Breckenridge, 1976) and indeed most of the performance research to date has focused on physiological responses to thermal stress while wearing MOPP 4. Numerous studies have determined that wearing CP clothing in warm-hot environments impedes evaporative cooling and results in thermal strain and a diminished physical work capacity (Goldman and Breckenridge, 1976; Goldman and Winsman, 1978; Goldman, 1983; Henane, Bittel, Viret and Morino, 1979; Joy and Goldman, 1988; Martin and Goldman, 1972). Auxillary cooling methods, however, have proven to be efective in heat removal while wearing MOPP 4 (Toner, White and Goldman, 1981; Toner, Drolet, Levell, Levine, Stroschein, Sawka and Pandolf, 1983). On the other hand, the human factor encumbrances associated with wearing CP clothing items may also compromise the performance of certain military tasks requiring cognitive problem solving skills or a high degree of manual dexterity or visual perception. Only a few studies have systematically investigated the influence of MOPP levels on cognitive, psychomotor and perceptual attributes common to many military performance tasks.

Fine and Kobrick (1987) investigated the effects of wearing MOPP 4 in hot (91F., 61%RH) and normal (55F., 35%RH) conditions compared to a NO MOPP control (70F., 35%RH) over eight hours duration on sustained, sedentary military task

performance. Their results showed that performance on cognitively based military tasks began to markedly degrade after four to five hours of exposure to the hot condition in MOPP 4. The MOPP 4 system by itself, however, (MOPP 4 at 55F., 35%RH) appeared to cause a decrement in performance at certain points in time, although, this effect was not consistently statistically significant. A serious limitation to detecting visual signals while wearing the MOPP 4 system was reported by Kobrick and Sleeper (1986). This degradation in functional vision occurred early and remained throughout eight hours of testing. Johnson and Sleeper (1986) studied the impact of wearing the CP mask and hood with rubber gloves on the soldier's ability to perform one-handed and two-handed tasks of manual dexterity. The results indicated that compared to bare handed conditions, manual dexterity was substantially poorer with the gloved hand. Moreover, the performance was unaffected by whether the soldier was wearing the mask with hood. Rauch, Witt, Banderet, Tauson and Golden (1986) investigated the effects of wearing MOPP 4, MOPP 2, and a NO-MOPP control, the Battle Dress Uniform (BDU), on three cognitive problem solving tasks over 24 hours of testing. The results showed that wearing MOPP 4 significantly impaired cognitive problem solving compared to MOPP 2 and the BDU control. The impairment attributed to the MOPP 4 condition, however, was observed in the rate of task (i.e., problem solving) completion in contrast to task accuracy. There were no significant differences between the MOPP 2 and BDU conditions. The MOPP 4 decrement alone suggested that performance may be compromised by wearing either the CP gloves or the CP mask or a combination of both. Hence, the decrement in performance while wearing MOPP 4 may be a function of impaired information input, such as visual distortions while wearing the mask, or by compromising the output by influencing manual dexterity while wearing the gloves and writing answers to cognitive problems. Unfortunately the experimental design did not permit manipulation of a glove vs mask effect while in the MOPP 4 configuration. The purpose of the present study, therefore, was to determine the effects of wearing the CP gloves vs wearing the CP mask vs wearing both the CP mask and gloves on a cognitive problem solving task.

### Method

Subjects. The subjects consisted of eight female and seven male volunteers from the U.S. Army Research Institute of Environmental Medicine. Subject ages ranged from 23 to 37 years.

Cognitive Test. A paper and pencil test of math computation required the subject to add three 2-digit numbers arrayed vertically. Math computation problems of this type are a measure of number facility and a common attribute in many military tasks. The math computation test had alternate forms and a sufficient number of problems to preclude anyone from completing the test during a two minute test administration.

Design and Procedure. The experimental design consisted of one between-subjects factor, SEX, with two levels and one within-subjects factor, CP condition, with four levels. The four CP conditions (levels) were: (1) wearing the CP gloves only; (2) wearing the CP mask only; (3) wearing both the CP mask and the CP gloves; and (4) bare handed and bare headed (i.e., not wearing the gloves and mask). Each subject was tested on alternate forms of the math computation test in each of the four MOPP conditions. The order of MOPP conditions was randomized for each subject. Every subject practiced twelve problems in each MOPP condition immediately prior to that testing session. Alternate forms of the math computation test was administered for a two minute test session prior to which subjects were instructed to "work as quickly and as accurately as possible." All testing was conducted at 72 degrees Fahrenheit.

### Results

Math computation scores consisted of the number of problems completed and the number of problems wrong based on a two minute test administration. The means and standard deviations of problems completed and problems wrong by CP level are presented in Table 1.

A 2 X 4 repeated measures analysis of variance revealed a significant main effect for the CP condition on the number of problems completed,  $F(3,42) = 4.23$ ,  $p < .02$ . The number of problems wrong did not significantly differ among CP levels. Likewise, there was no significant main effect for SEX and no significant SEX by CP interaction for problems completed or problems wrong.

A Least-significant difference test was performed for posteriori contrasts on the significant main effect of CP on problems completed. The post hoc analysis revealed two significant contrasts. Wearing both the CP mask and gloves resulted in a significantly lower number of problems completed in contrast to the bare handed/bare headed condition,  $t(15) = 3.21$ ,  $p < .01$ , and wearing the CP gloves only resulted in a significantly lower number of problems completed in contrast to the bare handed/bare headed condition,  $t(15) = 3.02$ ,  $p < .01$ . Figure 1 depicts the group means of math computation problems completed for the CP levels.

### Discussion

The results of the present study show that wearing the CP mask and gloves or wearing the CP gloves only significantly degrades the rate of completing a written cognitive task when compared to the bare handed-bare headed control. Differences between the CP levels should be attributed to the human factor encumbrances (i.e., limitations of manual dexterity and sensory-perceptual capabilities) associated with wearing the mask and gloves. In a recent study, Johnson and Sleeper (1986) found that compared to a bare handed condition, fine finger manual dexterity was substantially poorer in a group wearing the CP glove. Furthermore, the performance between bare handed and gloved conditions remained the same regardless of wearing the CP mask with hood. In the present study, wearing the mask only, did not produce significant performance decrements. The performance decrement observed while wearing the gloves or while wearing both the gloves and mask is likely due to the greater

amount of time required to write three digit answers using paper and pencil while wearing CP gloves. This type of performance decrement may be largely attributed to an impairment in information output (i.e., writing three digit answers) and not in the processing of cognitive information itself. Furthermore, since there was no main effect of CP level on computation errors it is doubtful that the accuracy of processing cognitive information is affected by wearing the CP items under subject-paced conditions and without thermal stress over a short period of time. Although the decrement in productivity is apparently due to wearing the CP gloves, the type and amount of information in the visual display of the stimulus could also influence productivity. For example, with number comparison tasks very little information is presented and abstracted from a single eye fixation compared to vertical addition in math computation. The greater amount of information presented in math computation tasks requires more time in visually acquiring and therefore processing the information. Hence, although output parameters involved in math computation productivity appear to be degraded the most in the gloved condition and in the gloved and mask condition, it is not unreasonable to suggest that the visual acquisition of certain types of stimulus information may also be sensitive to degradation while wearing the mask.

In summary, the results show that wearing the CP mask and gloves or wearing the CP gloves only significantly degraded the rate of completing a written cognitive task when compared to the bare headed-bare handed control. Wearing the mask alone did not produce significant performance decrements. The accuracy of the completed tasks were not significantly influenced by wearing combinations of the mask and gloves. The results of the present study have some implications on expected decrements in military performance while wearing MOPP gear. Threat doctrine will employ persistent agents in the Division Rear Area to disrupt combat service support. The speed of performing logistical tasks of short duration while wearing the CP gloves may require 10% longer to complete compared to a bare handed condition. It is important to note that although subjects in the present study were permitted practice trials in each CP configuration, performance was not intended to reach asymptote; that was not the purpose of the study. The personal observation of the authors has been that soldiers in field units spend little time practicing routine duties/tasks in MOPP 4 or while wearing the mask and gloves. Therefore, the present study was undertaken to determine the effects of wearing CP items on a familiar, but not a well practiced, task.

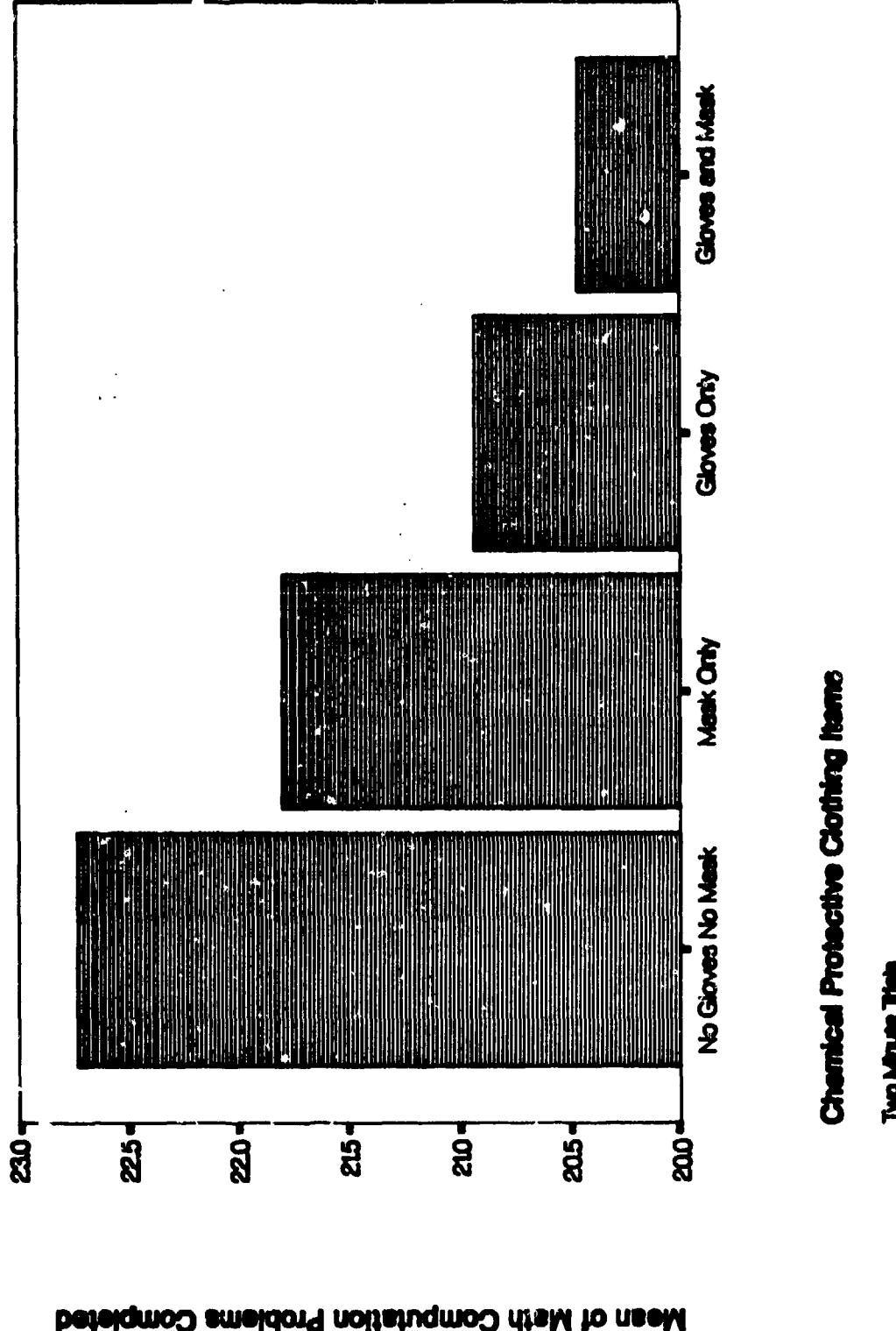
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Figure 1

## The Effects of Wearing the Chemical Protective Mask and Gloves on the Rate of Cognitive Problem Solving Paper & Pencil Math Computation



**Table 1**  
**Means and Standard Deviations of Math Computation Problems by  
 Subjects Wearing Combinations of the Chemical Protective  
 Gloves and Mask**

		Chemical Protective Clothing Items		
		Bare Head	Gloves Only	Mask Only
		Bare Hands	Gloves and Mask	Bare Mask
<b>Math Problems Completed      for a Two Minute      Trial</b>		22.7 5.6	28.9 5.2	28.5 4.4
<b>Math Errors for a Two      Minute Trial</b>		1.2 1.4	.7 .8	.7 1.6

N=15

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